CALS TEST NETWORK

CTN Report 93-003

Report on Prototype Design IETM

16 December 1992

Prepared for the CALS Test Network
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REPORT ON PROTOTYPE DESIGN

16 DECEMBER 1992

FINAL

Prepared by:

Department of the Army
PM JCALS

Joint
Computer-aided Acquisition
and Logistic Support (JCALS)

CALS Technology Center (CTC)

REPORT ON PROTOTYPE DESIGN

CONTRACT NO.: DAAB07-89-D-A047
TASK NO.: 92-014

16 December 1992

FINAL

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EXECUTIVE SUMMARY

Major efforts are underway within the Department of Defense (DoD) and the joint services to develop and transition technology which will speed the origination and exchange of information required to conduct day to day operations. A major focus of these efforts are Interactive Electronic Technical Manuals (IETMs).

IETMs automate the diagnostics and maintenance of a defense system and may use an expert system to perform diagnostics. Draft IETM specifications are being reviewed and pilot studies to identify portable maintenance aid (PMA) platforms are underway.

The purpose of this task is the development of a prototype IETM based on the (draft) General Content, Style, Functionality and User Interaction (MIL-M-GCSFUI) and IETM Data Base (MIL-D-IETMDB) Military Specifications. The prototype will provide a framework for evaluating the proposed standards and whether they are adequate for the creation of a viable IETM using commercial off-the-shelf (COTS) software. Unlike prior attempts to develop IETMs, this effort utilizes COTS software which is part of the JCALS system.

The prototype integrates a hypertext browser and a model-based expert diagnostic system. The user may optionally select the expert system to perform diagnostics on a defense system. The prototype system will be interactive and context sensitive. The data used for developing the IETM data base and demonstrating the prototype system are from the Air Force Technical Orders for the Communications System of the F-16 C and D aircraft.

This report details design considerations for the preparation of the technical data used to develop the IETM data base, the tailoring of the hypertext browser to operate according to the IETM specifications, and the integration of the model-based expert system. The proposed user interface design is included as an appendix to this report.

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SECTION 1
INTRODUCTION

1.1 BACKGROUND

Major efforts are underway within the Department of Defense (DoD) and the services to develop and transition technology which will speed the origination and exchange of information required to conduct day to day operations. Programs such as Joint Computer-aided Acquisition and Logistic Support (JCALS) are focusing on developing the capability to exchange technical information digitally in a paperless mode. A major focus for future dissemination of digital data is Interactive Electronic Technical Manuals (IETMs).

IETMs automate the diagnostics and maintenance of a defense system. IETM data is optimally arranged and formatted for interactive screen presentation to end-users. IETMs may or may not use an expert system to perform diagnostics on a defense system. Numerous efforts related to IETMs are ongoing. Draft IETM specifications are being reviewed; pilot studies are underway to define and identify portable maintenance aid (PMA) platforms.

Products automating the conversion of Standard Generalized Markup Language (SGML)-tagged technical information to easily navigated hypermedia applications are available. An expert system-based fault isolation and diagnostic tool linked to such an application would allow the JCALS system to achieve a wide range of IETM capabilities and provide empirical data for evaluating and improving the IETM specifications.

1.2 PURPOSE

The purpose of this task is development of a prototype IETM based upon the (draft) General Content, Style, Format and User-Interaction (MIL-M-GCSFUI) and IETM Data Base (MIL-M-IETMDB) Military Specifications. The prototype will provide a framework for evaluating the proposed standards and show whether they are adequate for creation of a viable IETM using commercial off-the-shelf (COTS) software.

1.3 SCOPE

The prototype consists of an interactive, context sensitive, electronic display system used to browse a hypertext of technical information and perform fault isolation and repair procedures. Fault diagnosis is performed either via predefined fault isolation procedures, or through the use of an expert diagnostic system.

Unlike prior attempts to develop IETMs, this effort utilized COTS tools which are part of the JCALS system and an IETM data base comprised of information tagged according to the Content Data Model (CDM). This prototype also incorporates a model-based expert diagnostic system which operates as an integrated component of the overall IETM.

The functionality incorporated into the prototype is based upon a subset of the features supported by the CDM and the GCSFUI. A number of factors influenced the choice of functions and are detailed in Section 3 of this report.

SECTION 2
SELECTION OF TECHNICAL DATA AND TOOLS FOR THE PROTOTYPE IETM

2.1 INTRODUCTION

This chapter identifies the criteria used to select the technical manuals (TMs) and tools used to develop a prototype IETM system. The TMs selected were Air Force Technical Orders (TOs) which provided diagnostic, maintenance, and other supporting technical data required for development of the IETM data base. The tools used for this task were all COTS products, including one which is part of the JCALS system design.

2.2 SELECTION OF TECHNICAL DATA

The CDM of MIL-D-IETMDB contains a content specific layer Document Type Definition (DTD) for organizational level Air Force TOs. Therefore, to obviate the need for developing a different content specific DTD, it was determined that Air Force organizational level manuals should be used in creating the IETM data base for this prototype. Another important factor was to chose a defense system with a complete set of TOs written to the latest applicable Air Force technical manual specifications. The final consideration was accessibility to the defense system library. With these criteria in mind, the F-16 Aircraft was chosen as the candidate defense system.

After discussions with subject matter experts (SMEs) at the F-16 library, it was determined that documentation for the F-16C and D is the most recent, complete set of TOs available. The SMEs were informed that this data would be used to create an IETM data base.

The F-16 Communications system was chosen for the prototype effort. With the aid of the SMEs, it was determined that the fault isolation, fault reporting, general systems, illustrated parts breakdown manuals, and various job guides contain the data required to develop an IETM data base.

After a more detailed analysis, the VHF subsystem was ultimately selected. The VHF subsystem data provide all the information necessary to model the IETM prototype. A list of the manuals and job guides used in the course of this task are contained in Section 5.

2.3 SELECTION CRITERIA FOR APPLICATION TOOLS

The process of developing this IETM prototype entails tagging selected portions of the chosen TOs, implementing an IETM browser (including the graphical user interface [GUI] and requisite hypertext), and defining a model for use by an expert system to aid in fault isolation. The following Sections describe the tools used to tag the data (Section 3.1), develop the IETM browser (Section 3.2) and define a dynamic fault isolation model for use by an expert system (Section 3.3).

2.3.1 SGML Parser and Authoring System

Exoterica Corporation's XGML CheckMark application is being used to markup the technical data and validate the tagged instances against the CDM. Although CheckMark is not part of the JCALS system, it is being used because of its availability at the CALS Technology Center at Ft. Monmouth, New Jersey. Moreover, the SGML tools which are part of the JCALS system (ArborText, Inc.'s ADEPT Series of tools) offer a higher level of functionality than required for this task. Nonetheless, the latter could have been substituted.

2.3.2 IETM Display System

Electronic Book Technologies' (EBT) DynaText application software will be used to create the IETM prototype. It has been selected as the IETM browser for the JCALS system by the JCALS contractor. There are numerous commercially available software applications which support development of an interactive, hypertext browser. DynaText was selected because one of the goals of this task is to assess the feasibility of using JCALS system COTS software to develop an IETM. There are three aspects of DynaText which were considered important to this task.

- DynaText operates on SGML-tagged documents.
- The application runs in the DOS/Microsoft Windows environment, as well as under DEC/ULTRIX.
- DynaText has a development tool kit which will be used to customize the application to interpret the CDM DTD tag set.

2.3.3 Expert System Diagnostic Tool

The expert system component of the prototype will be developed using the I-CAT™ (Intelligent Computer-Aided Troubleshooting) software produced by Titan Software. The salient feature of I-CAT is its use of a model-based approach to fault isolation and diagnosis. This is in contrast to the rule-based method embodied in the logic trees in the paper-based fault isolation technical manuals. Equally important is the technical expertise which Titan Software provides to aid in translating the rule-based approach to a model-based analysis. Finally, I-CAT runs under DOS/Microsoft Windows and it is capable of being integrated with DynaText in that environment.

SECTION 3
DESIGN OF THE PROTOTYPE IETM

3.1 OVERVIEW

The IETM prototype will be comprised of customized versions of the DynaText Browser and the I-CAT expert system running in a Microsoft Windows 3.1 environment. Functionally, DynaText and I-CAT will operate as peers in terms of the exchange of messages. Data is passed between the two applications using Microsoft Windows' Dynamic Data Exchange protocol. The interchange between DynaText and I-CAT follow below (note: "browser" refers to DynaText and "expert system" refers to I-CAT).

- The browser passes control to the expert system when the user selects dynamic fault isolation.

- When the user selects a test point or a module, the expert system notifies the browser with a message which indicates the type of information (descriptive, graphics, procedural, or parts) and a string which uniquely identifies the item requested. In response to the message, the browser displays the data or initiates a test or repair procedure.

- If a procedure or test has been requested, the expert system suspends execution awaiting a message from the browser indicating the procedure or test's outcome.

In terms of window management, DynaText will define and manage the screen layout and I-CAT will run in a window within that layout. With the exception of pointer device actions in the I-CAT window, all user input will be mediated by DynaText and passed to I-CAT as necessary.

The following Sections detail the implementation requirements for the DynaText and I-CAT applications.

3.2 IMPLEMENTING AN EXPERT SYSTEM-BASED DIAGNOSTIC TOOL

I-CAT supports dynamic fault isolation by using the outcome of trouble-shooting procedures to select successive tests as it attempts to isolate a faulty component. Underlying this process is a model of the components of the system undergoing maintenance. The model embodies the hierarchical relationships among components of the system and the dependencies among them. The major effort in implementing I-CAT for the prototype is in developing a model of the Communications system and its component subsystems.

Ideally, the system model would be developed with the aid of F-16 Aircraft subject matter experts (SMEs). In the absence of such experts, the model will be developed by extrapolating

the information contained in the technical manuals which describe the Communications system and its subsystems (UHF, VHF, Secure Voice and Interphone).

It will also be necessary to develop several functions, using I-CAT's development language (a LISP interpreter), to facilitate DDE exchange of messages with DynaText.

3.3 IMPLEMENTING THE DISPLAY SYSTEM

The basic DynaText system supports creation of an "electronic book" browser which uses SGML-tagged files as input and creates a hypertext using an EBT proprietary scheme.

To develop the prototype IETM, the basic DynaText browser will be enhanced to interpret CDM-tagged documents. Of particular importance is the creation of a hyperdocument containing text and graphics data which are based upon the hyperlink mechanism as defined in the CDM.

An important characteristic of the prototype is the dynamic display of information as a function of user interaction with the IETM. Information selected for display depends upon input items such as: identity of the aircraft, outcome of a test, skill level, or selection of a hyperlink. In general, DynaText will be a state-driven system where its functioning and selection of information will depend upon the current system state.

The figures located in Appendix A illustrate the anticipated user interface for the prototype IETM.

3.4 PREPARATION OF THE TECHNICAL DATA

Technical information used in the IETM prototype includes both ASCII text and graphics. Textual data are scanned in and processed by an Optical Character Recognition (OCR) application to generate ASCII text files. Graphics data are scanned in and processed by several image processing applications to generate a final CALS-compliant raster image. The following Sections describe the steps required to prepare text and graphics from the Air Force TOs for use by the IETM prototype.

3.4.1 Text Data

The transfer of text data from paper form to a computer-based format entails two stages of translation. First, the paper document is digitized to produce a raster image; next, the raster image is processed by a OCR application to produce ASCII text data.

This translation process is not without its share of problems. If the paper document is scanned in at too low a resolution, much of the image's detail may be lost, and, consequently, much of the text may be translated inaccurately. However, if the document is scanned in at too high a resolution, the time taken to digitize a single page may be dramatically increased, the images may be too large for the OCR package to handle, and the translation time for each digitized image is expanded.

Once the ASCII text data are produced, it must be examined by the developers to verify the accuracy of the data. This essentially involves proof-reading the ASCII text data and/or running a spell-checker against the text file.

3.4.2 Graphics Data

All of the graphics used in the prototype are black and white line drawings. The graphics are scanned in at 300 dots-per-inch (dpi) and stored in uncompressed Tagged Image File Format (TIFF). This specific scanning resolution was selected to maximize the details of the scanned image. The graphics are cleaned and cropped to remove unnecessary information and then re-sized. The dimensions of the graphic must be chosen so as to retain the detail of useful information and support the requirements of the user interface. The graphic file is processed by a TIFF compression utility to produce a CCITT Group 4 raster image. The compressed file is then processed by a second TIFF utility to yield a CALS-compliant header for the file.

Another consideration to be addressed with graphics data is the identification of "hotspots." Each graphic may have multiple hotspots defined for it. The hotspots will provide a mechanism to reference related information. The hotspot will be defined by X and Y coordinates for the upper-left and lower-right hand corners of a rectangular region on the graphic.

3.4.3 Tagged Document

The documents to be tagged for the IETM prototype are listed in Section 5. Each document provides information for the diagnostics and maintenance of the VHF subsystem of the Communication System for the F-16 Aircraft. Since the scope of the IETM prototype is limited to the VHF subsystem, only the information relevant to that subsystem has been targeted for inclusion in the prototype. A brief description of each technical manual follows.

- The General Systems manual "gives organizational level data for support of the communications system of the F-16" to include "system description, system theory, and other data in support of the F-16 communications system."[1]

- The Fault Reporting manual is "a debriefing aid which provides the flight crew and ground personnel with the detailed technical data needed to expedite the identification, analysis, and reporting of fault reportable aircraft system malfunctions to maintenance."[2]

- The Fault Isolation manual provides "fault identification, description, and isolation procedures for the [F-16] communications system."[3]

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[1]T.O. 1F-16CG-2-23GS-00-1

[2]T.O. 1F-16CG-2-00FR-00-1

[3]T.O. 1F-16CG-2-23FI-00-1

- The Illustrated Parts Breakdown manual provides a detailed maintenance parts list for the communications systems of the F-16C/D aircraft.

- The Job Guide manual "provides start-to-finish, step-by-step maintenance actions for the F-16 VHF communications system components."[4]

[4]T.O. 1F-16CG-2-23JG-30-1

SECTION 4
GLOSSARY OF TERMS AND ABBREVIATIONS

CDM	Content Data Model
COTS	Commercial Off-The-Shelf
DOD	Department of Defense
dpi	Dots Per Inch
DTD	Document Type Definition
EBT	Electronic Book Technologies
GCSFUI	General Content, Style, Format and User-Interaction
GUI	Graphical User Interface
IETM	Interactive Electronic Technical Manual
IETMDB	IETM Data Base
JCALS	Joint Computer-aided Acquisition and Logistic Support
OCR	Optical Character Recognition
PMA	Portable Maintenance Aid
SGML	Standard Generalized Markup Language
SME	Subject Matter Expert
TIFF	Tagged Image File Format
TM	Technical Manual
TO	Technical Order

SECTION 3
REFERENCES

United State Department of Defense, NSWC and AL/HRG, MIL-D-IETMDB *Data Base, Revisable: Interactive Electronic Technical Manuals, for the Support of,* 11 May 1992

United State Department of Defense, DTMB/AFMC/MRSA, MIL-M-GCSFUI Manuals, *Interactive Electronic Technical: General Content, Style, Format, and User-Interaction Requirements,* 31 July 1992

United States Air Force, T.O. 1F-16CG-2-00FR-00-1, *F16C Communications Systems Fault Reporting Manual*

United States Air Force, T.O. 1F-16CG-2-23FI-00-1, *F16C Communications Systems Fault Isolation Manual*

United States Air Force, T.O. 1F-16CG-2-23GS-00-1, *F16C Communications Systems General Systems Manual*

United States Air Force, T.O. 1F-16CG-4-23, F16C *Communications Systems Illustrated Parts Breakdown*

United States Air Force, T.O. 1F-16CG-2-23JG-20-1 *(UHF) F16C Job Guides*

United States Air Force, T.O. 1F-16CG-2-23JG-30-1 *(VHF) F16C Job Guides*

United States Air Force, T.O. 1F-16CG-2-23JG-40-1 *(Interphone) F16C Job Guides*

United States Air Force, T.O. 12R2-2AIC25-2, *Field Level Technical Orders, Field Maintenance, Intercom Set AN/AIC-25-2*

United States Air Force, T.O. 12R2-2AIC25-4, *Illustrated Parts Breakdown, Intercom Set AN/AIC-25-2*

APPENDIX A

ILLUSTRATIONS OF IETM USER INTERFACE

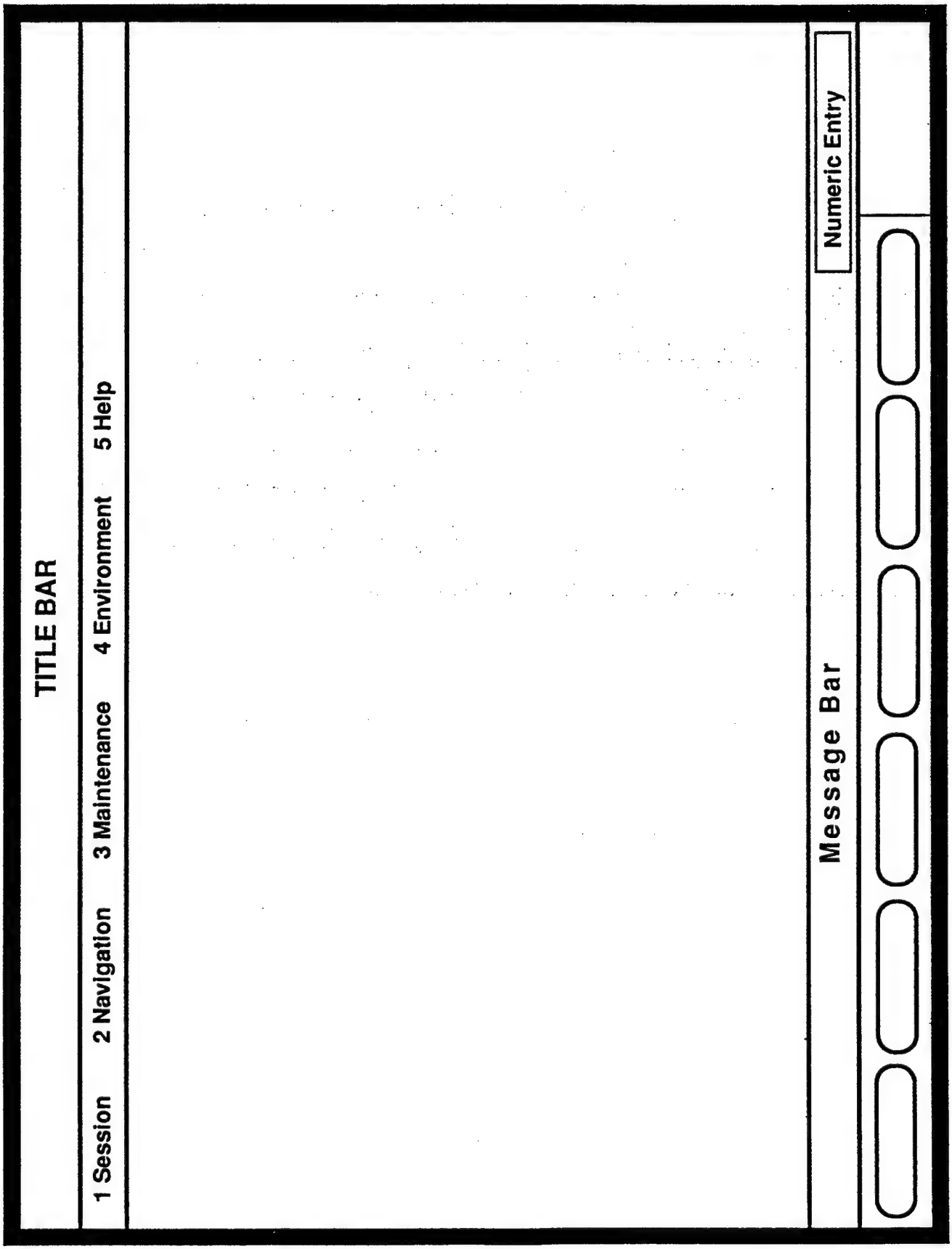

TITLE BAR
1 Session
2 Navigation
3 Maintenance
4 Environment
5 Help
Message Bar
Numeric Entry

Figure A-1

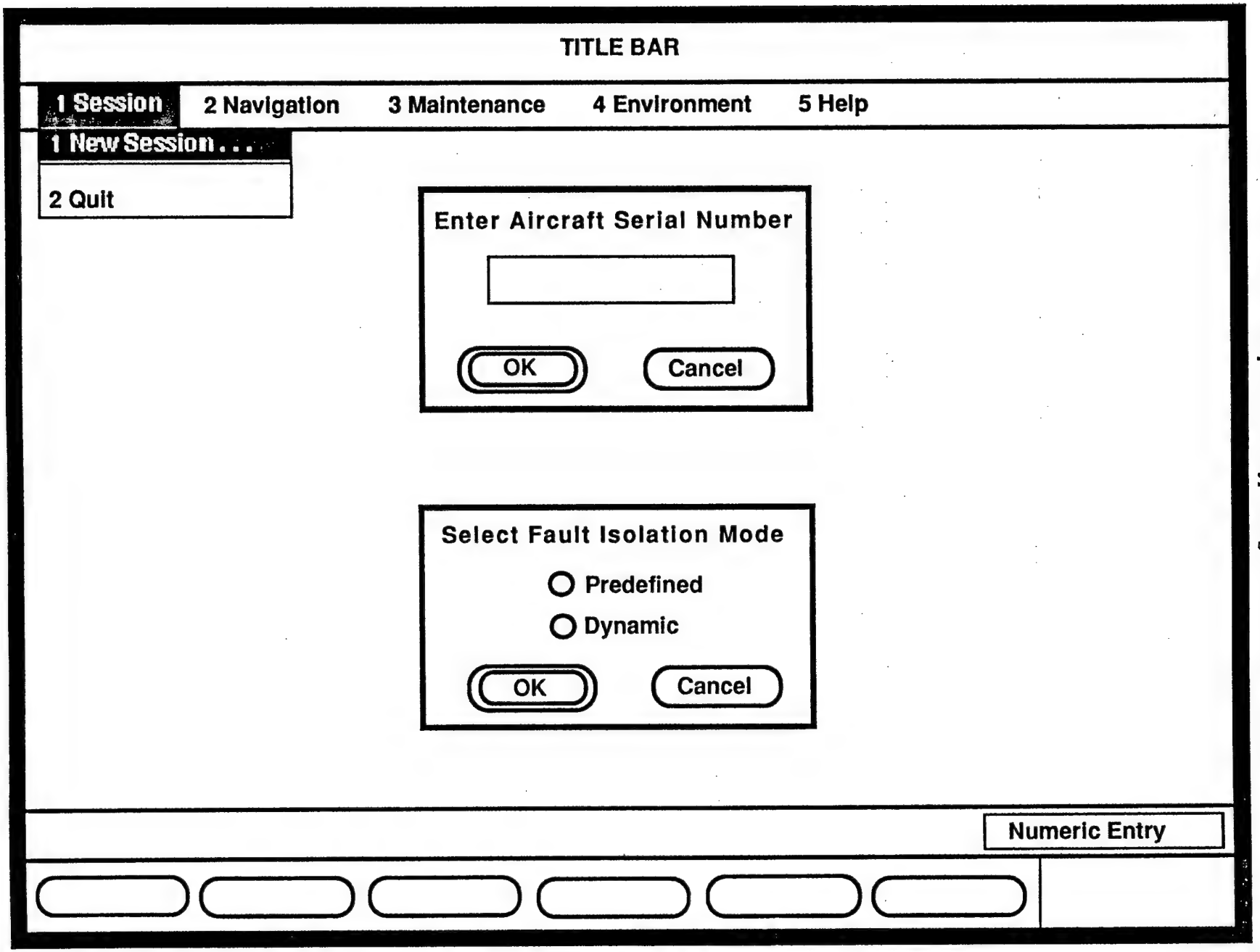

TITLE BAR
1 Session
2 Navigation
3 Maintenance
4 Environment
5 Help
1 New Session . . .
2 Quit
Enter Aircraft Serial Number
OK
Cancel
Select Fault Isolation Mode
Predefined
Dynamic
OK
Cancel
Numeric Entry

Figure A-2

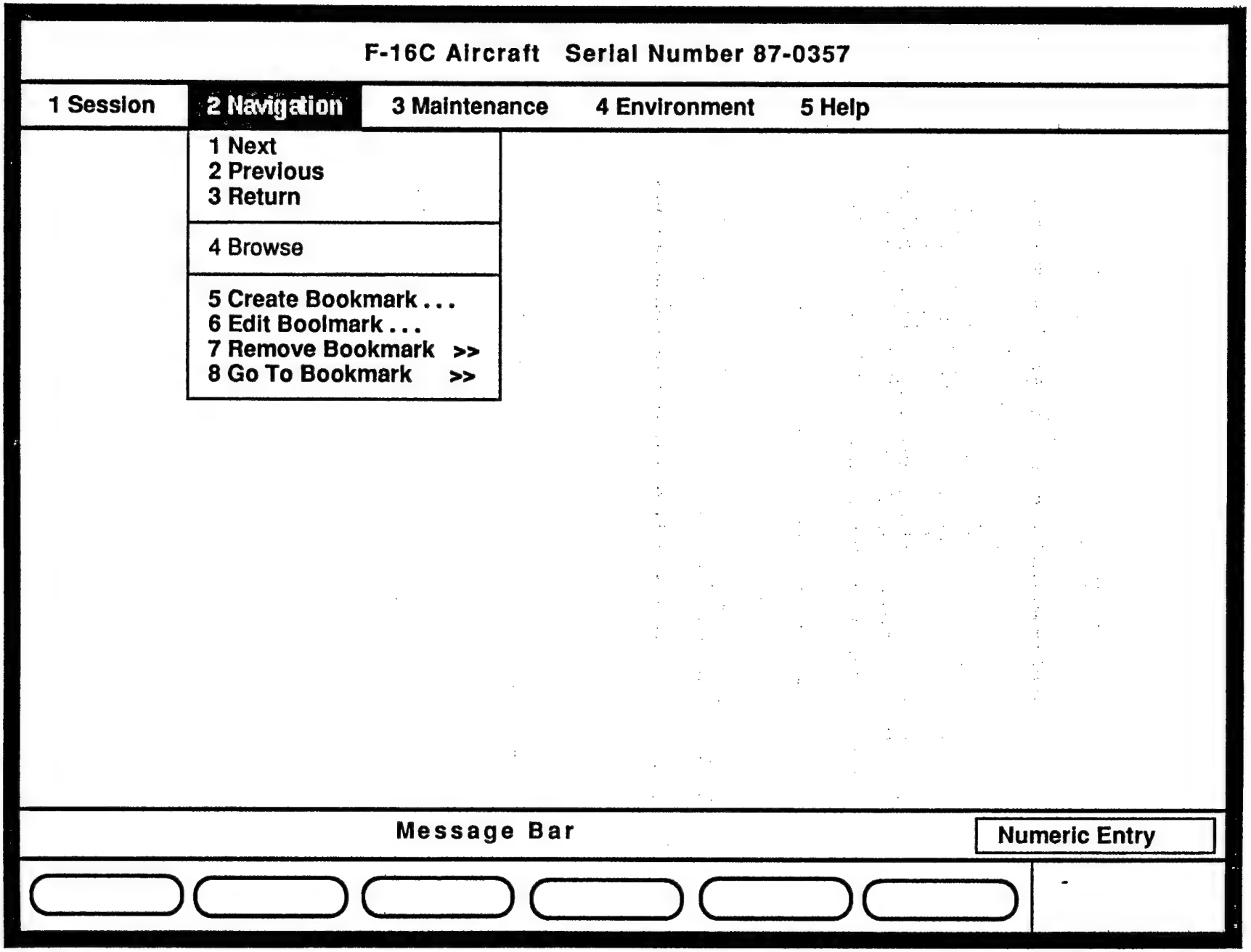

F-16C Aircraft Serial Number 87-0357
1 Session
2 Navigation
3 Maintenance
4 Environment
5 Help
1 Next
2 Previous
3 Return
4 Browse
5 Create Bookmark . . .
6 Edit Boolmark . . .
7 Remove Bookmark >>
8 Go To Bookmark >>
Message Bar
Numeric Entry

Figure A-3

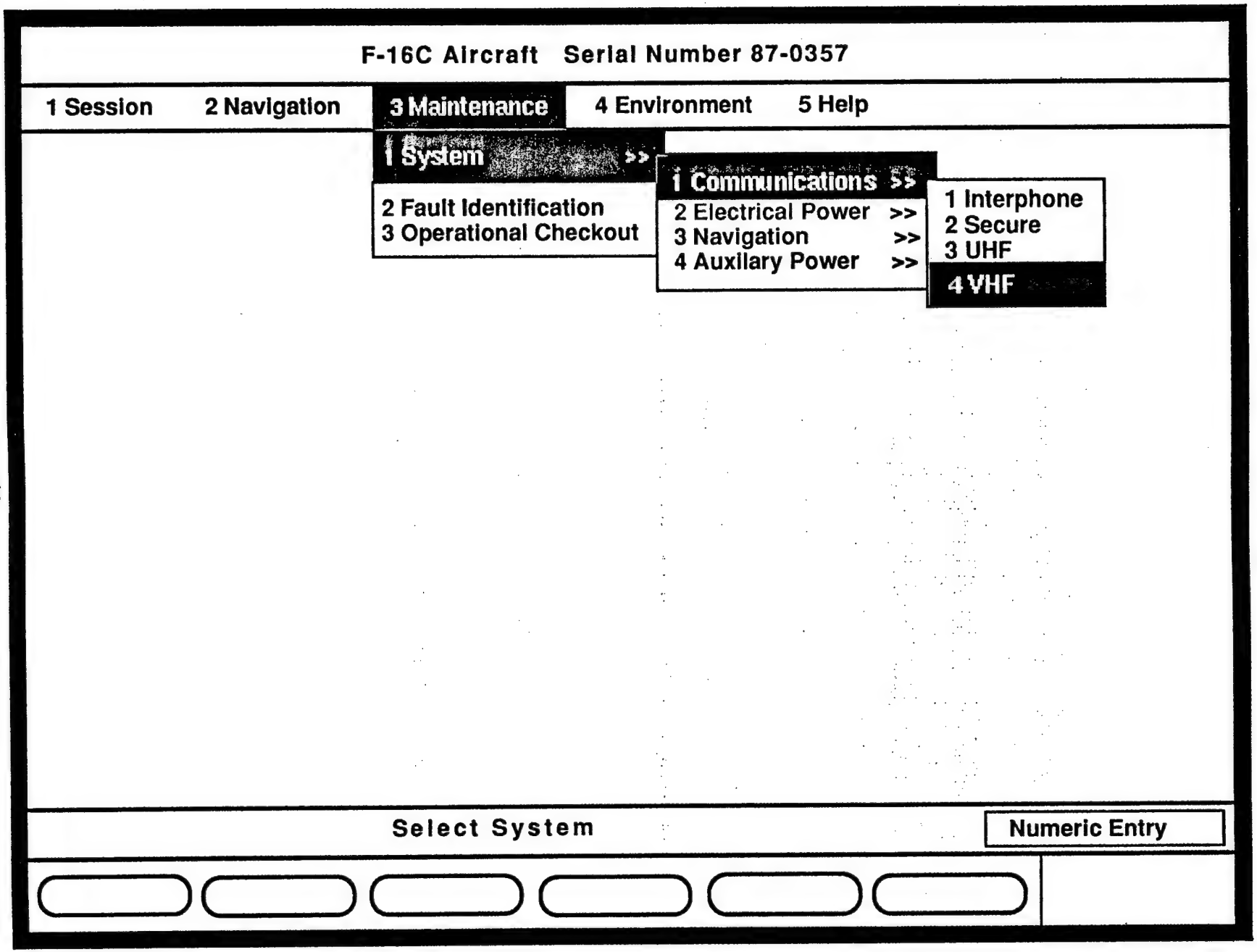

F-16C Aircraft Serial Number 87-0357
1 Session
2 Navigation
3 Maintenance
4 Environment
5 Help
1 System >>
2 Fault Identification
3 Operational Checkout
1 Communications >>
2 Electrical Power >>
3 Navigation >>
4 Auxilary Power >>
1 Interphone
2 Secure
3 UHF
4 VHF
Select System
Numeric Entry

Figure A-4

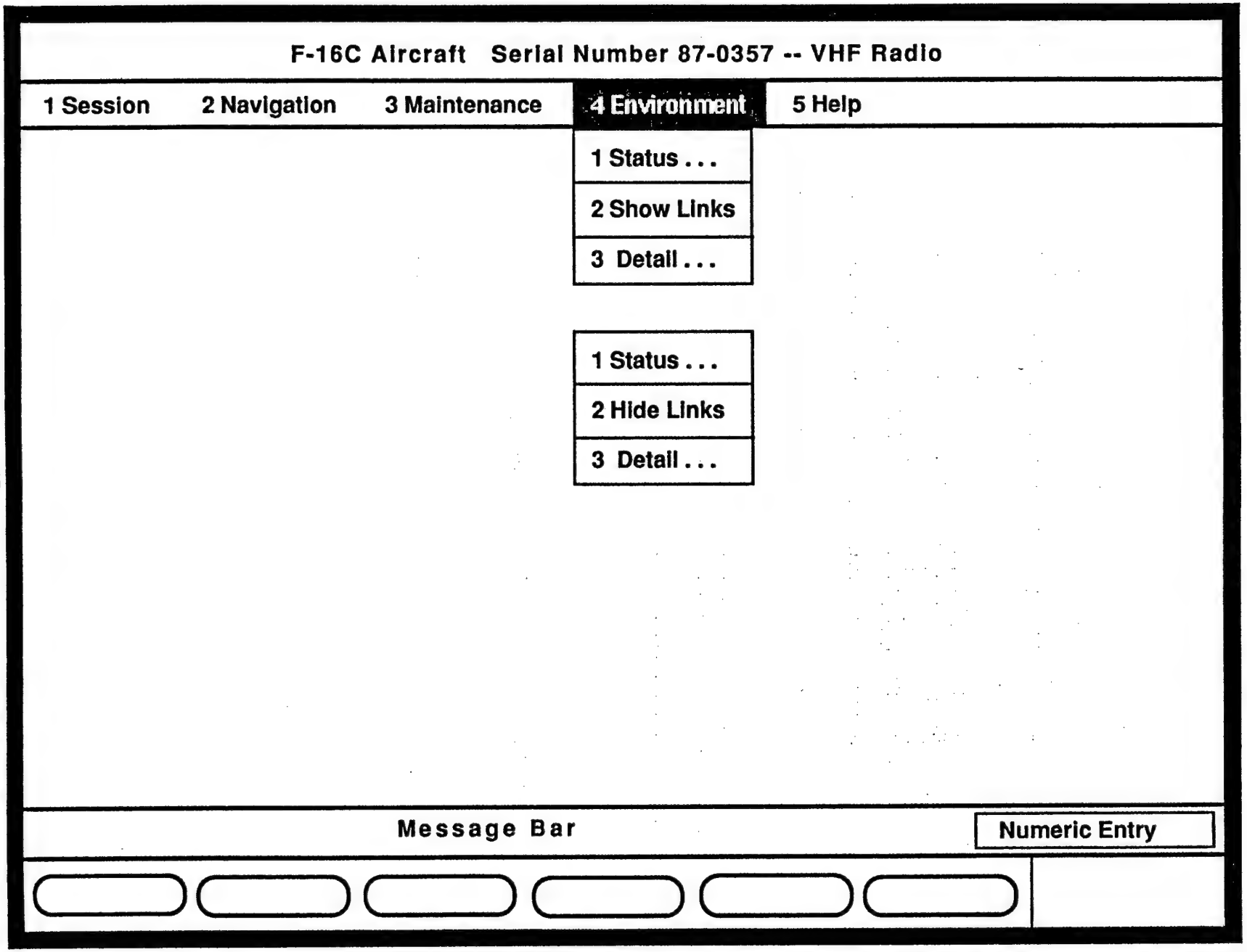

F-16C Aircraft Serial Number 87-0357 -- VHF Radio
1 Session
2 Navigation
3 Maintenance
4 Environment
5 Help
1 Status . . .
2 Show Links
3 Detail . . .
1 Status . . .
2 Hide Links
3 Detail . . .
Message Bar
Numeric Entry

Figure A-5

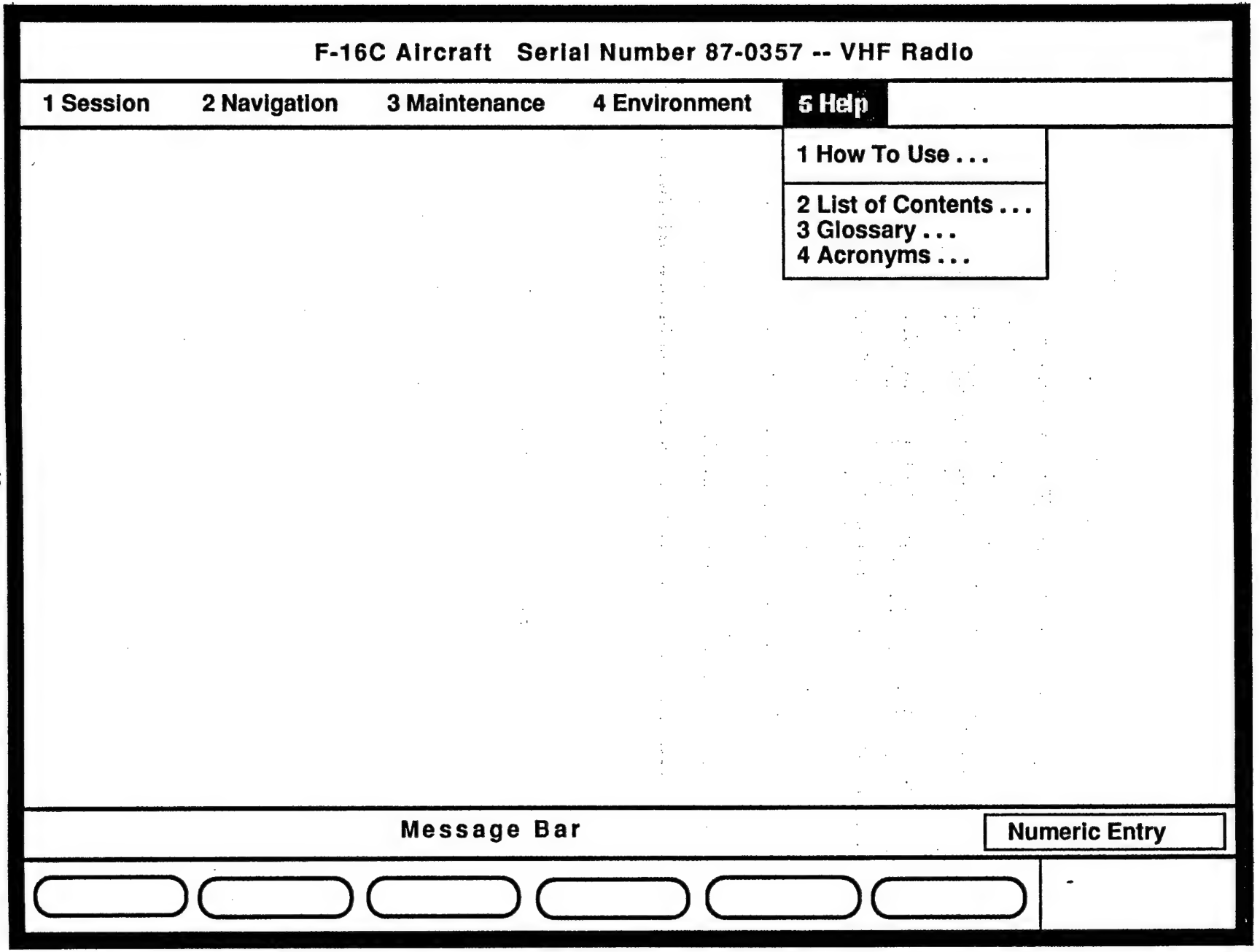

F-16C Aircraft Serial Number 87-0357 -- VHF Radio
1 Session
2 Navigation
3 Maintenance
4 Environment
5 Help
1 How To Use . . .
2 List of Contents . . .
3 Glossary . . .
4 Acronyms . . .
Message Bar
Numeric Entry

Figure A-6

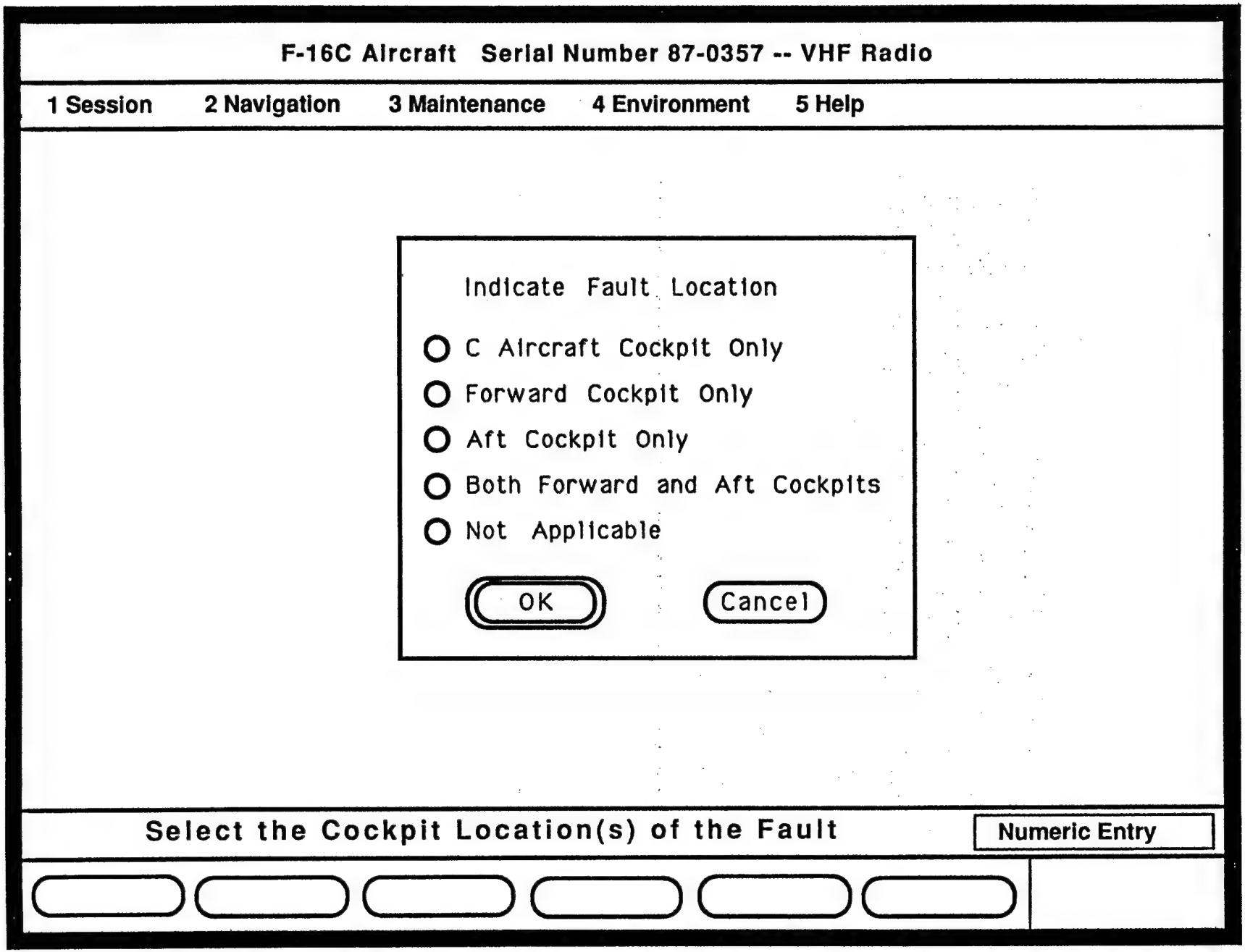

F-16C Aircraft Serial Number 87-0357 -- VHF Radio
1 Session
2 Navigation
3 Maintenance
4 Environment
5 Help
Indicate Fault Location
C Aircraft Cockpit Only
Forward Cockpit Only
Aft Cockpit Only
Both Forward and Aft Cockpits
Not Applicable
OK
Cancel
Select the Cockpit Location(s) of the Fault
Numeric Entry

Figure A-7

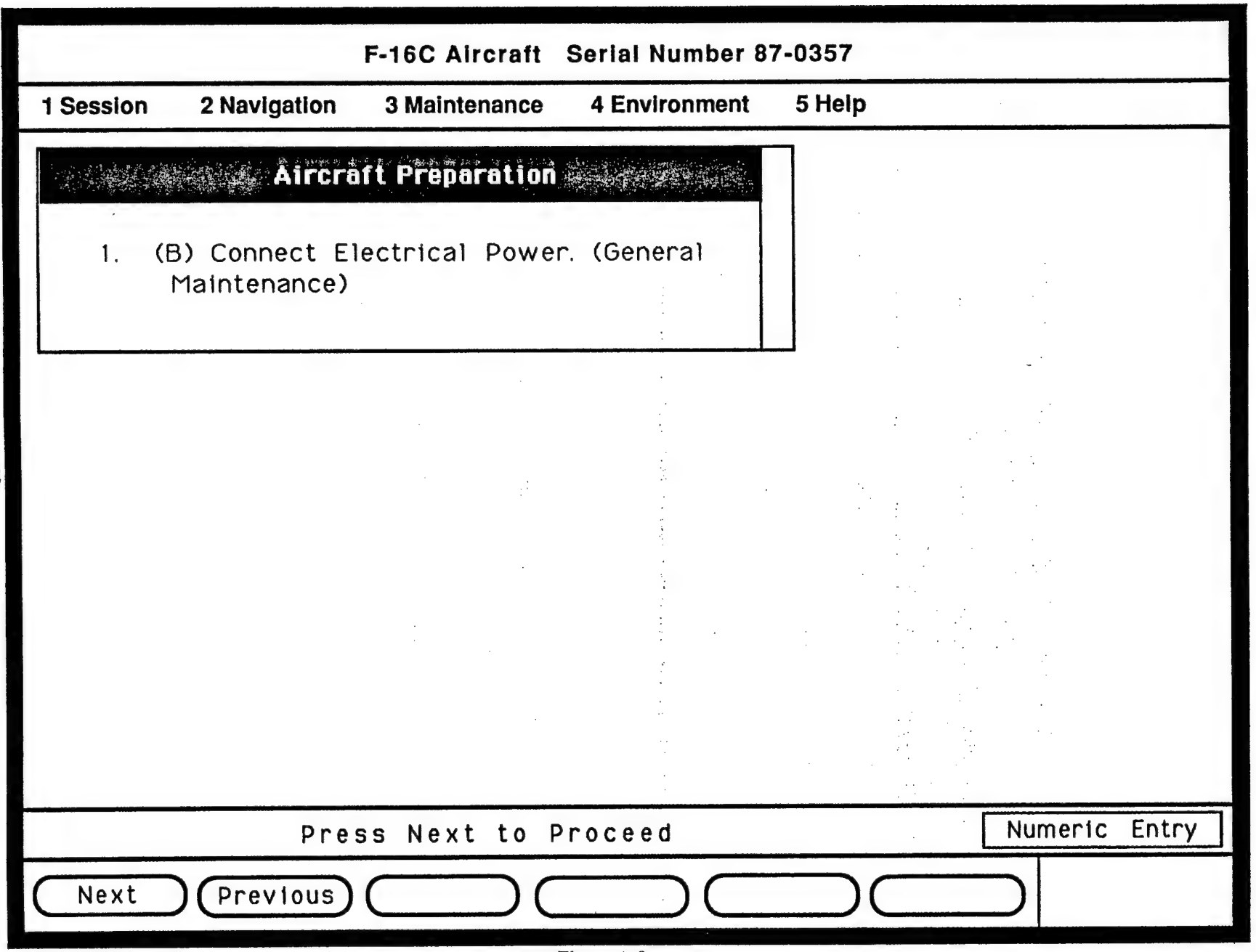

F-16C Aircraft Serial Number 87-0357
1 Session
2 Navigation
3 Maintenance
4 Environment
5 Help
Aircraft Preparation
1. (B) Connect Electrical Power. (General Maintenance)
Press Next to Proceed
Numeric Entry
Next
Previous

Figure A-8

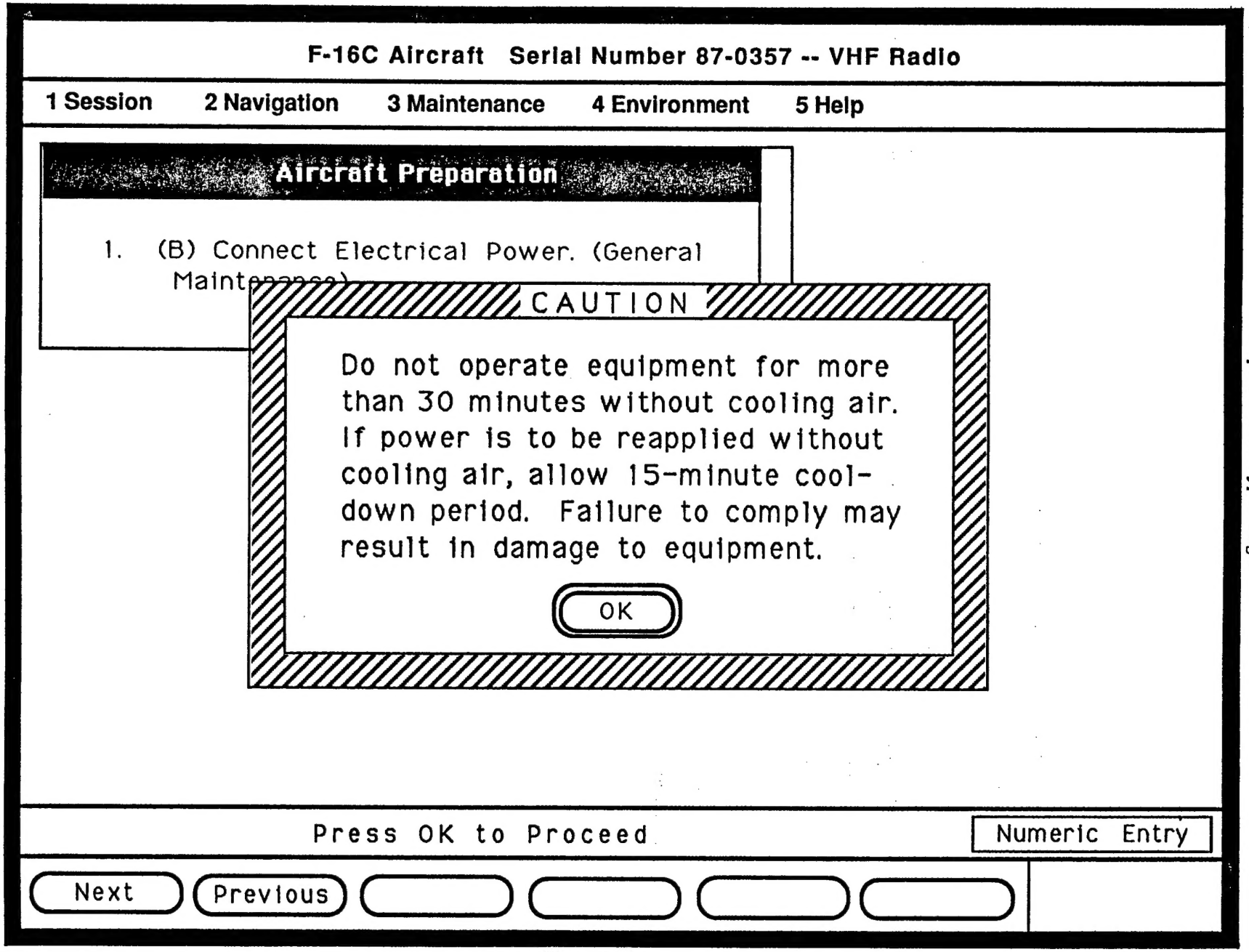

F-16C Aircraft Serial Number 87-0357 -- VHF Radio
1 Session
2 Navigation
3 Maintenance
4 Environment
5 Help
Aircraft Preparation
1. (B) Connect Electrical Power. (General
CAUTION
Do not operate equipment for more than 30 minutes without cooling air. If power is to be reapplied without cooling air, allow 15-minute cool-down period. Failure to comply may result in damage to equipment.
OK
Press OK to Proceed
Numeric Entry
Next
Previous

Figure A-9

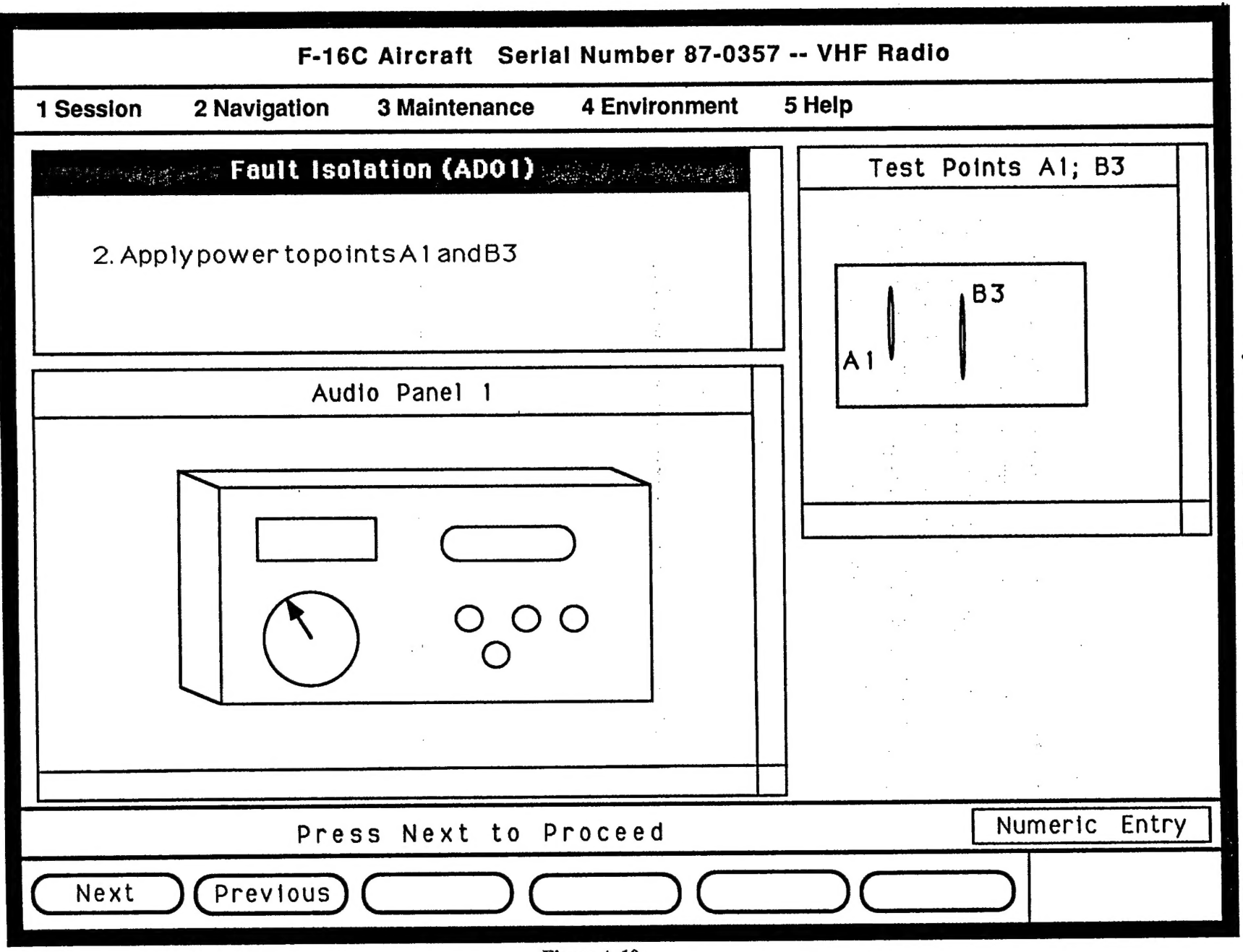

F-16C Aircraft Serial Number 87-0357 -- VHF Radio
1 Session
2 Navigation
3 Maintenance
4 Environment
5 Help
Fault Isolation (AD01)
2. Apply power to points A1 and B3
Test Points A1; B3
B3
A1
Audio Panel 1
Press Next to Proceed
Numeric Entry
Next
Previous

Figure A-10

F-16C Aircraft Serial Number 87-0357 -- VHF Radio

1 Session 2 Navigation 3 Maintenance 4 Environment 5 Help

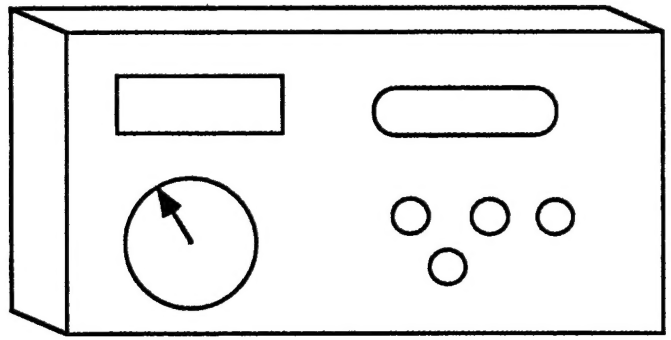
Fault Isolation (AD01)

4. Verify continuity

Continuity Test

5. If the bulb lights, there is continuity.

Audio Panel 1



Enter Outcome of Test (OK or Not OK)

Numeric Entry

Next | Previous | | | OK | Not OK

Figure A-11

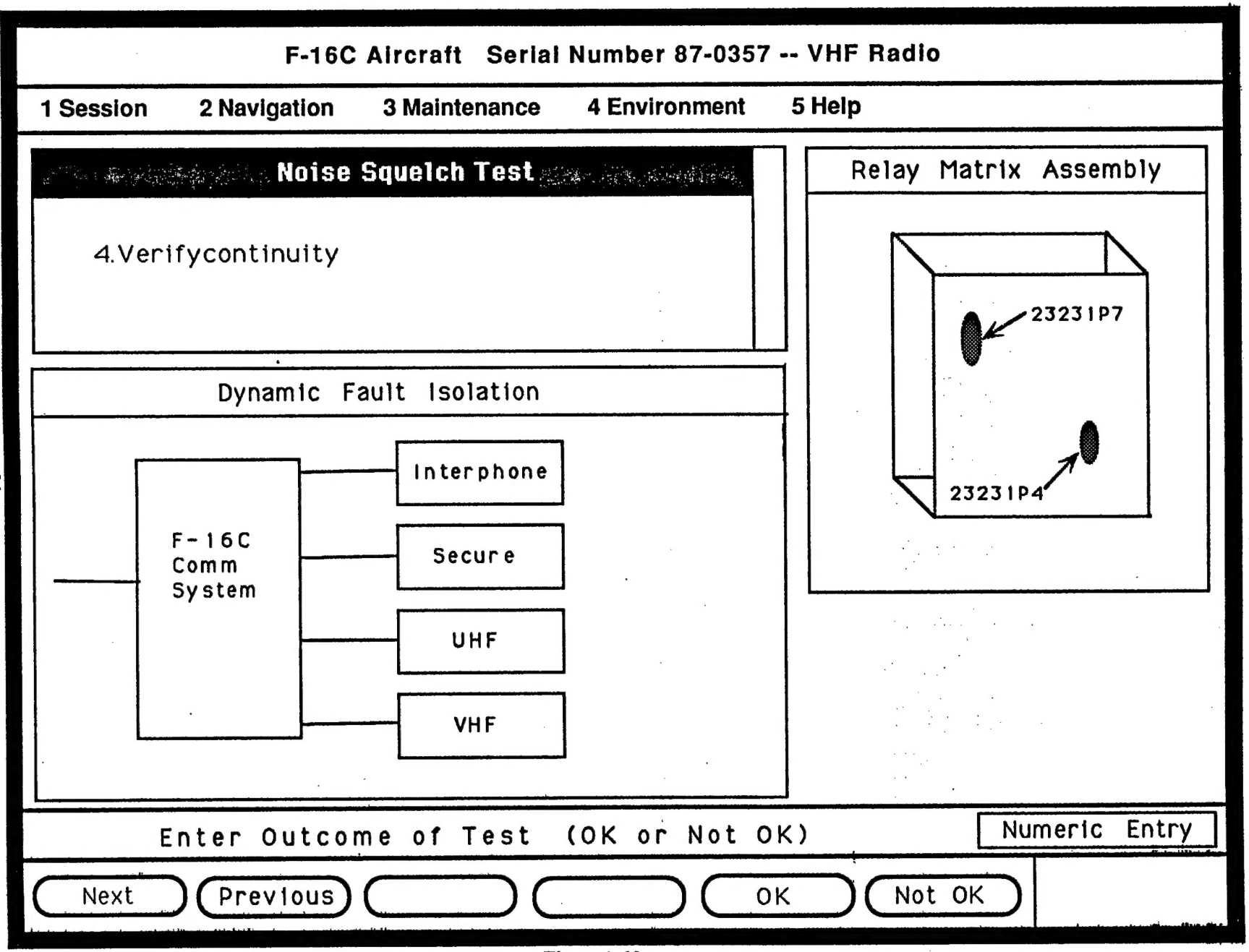

F-16C Aircraft Serial Number 87-0357 -- VHF Radio
1 Session
2 Navigation
3 Maintenance
4 Environment
5 Help
Noise Squelch Test
4.Verifycontinuity
Relay Matrix Assembly
23231P7
23231P4
Dynamic Fault Isolation
F-16C Comm System
Interphone
Secure
UHF
VHF
Enter Outcome of Test (OK or Not OK)
Numeric Entry
Next
Previous
OK
Not OK

Figure A-12